Environmental Characterization of Mine Countermeasure Test Ranges: Hydrography and Water Column Optics

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LONG-TERM GOALS

We wish to observe the hydrographic factors that regulate optical changes in near-shore water columns and support companion laser imaging system tests. The physical, biological and optical oceanographic data developed under this project will be used as input to optical and environmental models to assess the performance characteristics of laser imaging systems.

OBJECTIVES

We proposed to characterize the physical, biological and optical fields present during deployments of the Streak Tube Imaging Lidar (STIL, Arete Associates) and two Laser Line Scanner systems (EOID, Raytheon Corp. and AQS-14, Northrop-Grumman). Our environmental characterization efforts were closely coordinated with Dr. Charles Mazel (measurements of benthic optical properties) and Dr. Ken Voss (measurements of the benthic bi-directional reflectance distribution function, water column point spread function and scattering phase function). Our data would also be valuable for sensor characterization and evaluation of sensor performance models.

APPROACH

Our field efforts centered on: 1) deployments of upward looking ADCP and near-bottom CTD/optics moorings along a transect within the test range, 2) ship based underway surface measurements of physical, biological and optical properties, 3) ship based station profiling and discrete water sampling as a function of depth for physical, biological and optical properties of the water column and 4) acquisition of 1km resolution satellite images for sea surface temperature and albedo (AVHRR) and ocean color parameters (SeaWiFS) in order to describe mesoscale oceanographic conditions present during the tests.

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14. ABSTRACT
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Upward looking ADCP and near-bottom CTD/optics moorings

We deployed two RD Instruments Workhorse upward looking Acoustic Doppler Current Profilers on trawl resistant frames with SeaBird SeaCat 19 CTD's, integrated WETSTAR fluorometers configured for chlorophyll and WET Labs C-Star 532nm transmissometers. Separate HOBI Labs *a* βeta meters (532nm) were attached to the frames in a position to avoid sigmal contamination from neighboring objects. These optics packages simultaneously measured chlorophyll fluorescence and the inherent optical properties (IOPs) of attenuation (c, m^{-1}), absorption (a, m^{-1}), backscatter (b_b, m^{-1}) and the volume scattering function at 140^o, all at 532nm. Data were logged internally at 10 minute intervals and downloaded at the end of the deployments.

Continuous underway surface mapping system

The ship's uncontaminated seawater system provided a debubbled flow stream to the underway system which measured physical, biological and optical parameters matching the moorings as well as incident spectral downwelling irradiance while the ship is underway. A Seabird SBE21 thermo-salinograph measured temperature and conductivity in the thermosalinograph housing, T and C measurements were co-registered in time using Seabird software. The SBE 21 also provided power to and logged analog signals from two external sensors and logged ship's navigational information through a NMEA 0183 input channel. A standing volume tank was used to house a WET Labs 532nm C-Star 25cm transmissometer, WET Labs ECO-AFL free volume *in situ* fluorometer configured for chlorophyll and HOBI Labs a-βeta meter (powered and logged separately). A Satlantic, Inc., OCR-507 seven channel sensor monitored incident solar irradiance. All sensors were logged at 30 second intervals. Surfer countouring software will be used to map properties in Lat/Lon space.

Physical, biological and optical measurements on station

Stations were occupied at the central marker of the target field four times per day prior to, between and after towing surveys with the laser imaging systems combined in a single tow body and at night in combination with Voss' PSF and GASM profiles. The profiling package consisted of an FSI Micro-CTD, WET Labs ac9 and Biospherical Instruments split PRR600 seven channel spectro-radiometer such that the vertical multispectral data matched the mooring and the underway systems. Niskin bottle samples were collected at the surface and within 2m of the bottom for discrete deter-minations of optically active substances such as chlorophyll and total suspended solids. Partitioned absorption of particles and CDOM were measured using spectrophotometric techniques on stored samples back at the laboratory.

Satellite imagery of mesoscale features during field exercises

The water masses surrounding the test range were expectes to be highly attenuating and spatially variable. To improve our spatial characterization of the region, we obtained NOAA AVHRR imagery acquired through the CoastWatch Gulf of Mexico Node to characterize the surface albedo and sea surface temperature fields. NASA SeaWiFS imagery was also be obtained in collaboration with Dr. Robert Arnone at NRL Stennis Space Center to characterize the chlorophyll and IOP/AOP fields at 532nm using NRL's analytical model image processing.

WORK COMPLETED

Field work off Panama City, FL, was performed aboard R/V Edwin Link from August 12 to 24, 2001. Hurricane Barry moved directly through the area one week prior to the beginning of field sampling significantly affecting water quality at the main transect site. The following measurements were obtained:

13 days of bottom mounted ADCP/CTD/optics records at ten minute intervals (two sites)

41 ac9/CTD profiles at main transect site

41 discrete Niskin bottle casts for particulate and dissolved absorption, pigments and TSS

23 profiles of spectral downwelling irradiance (E_d) and upwelling radiance (E_u)

8 nights of underway surface property mapping

12 days of SeaWiFS ocean color coverage in the month of August, 2001.

RESULTS

In general, water transparency improved over time during the second and third weeks after the passage of hurricane Barry. The vertical distribution of optical properties at the main transect site were found to be nearly homogeneous in the upper 15m with a turbid layer extending 5m above the bottom. Figure1 shows the distribution of K_{532} (m^{-1}) in the Gulf of Mexico as viewed by SeaWIFS imagery for a date in the middle of the cruise. Imagery for the month of August does not suggest a great deal of change in surface optical properties for the region of the transect site. To date, we have processed optical data at 532nm (the laser imaging wavelength) from the first week of mooring data (Figure 2) and profiles. Values from the different systems are comparable and coherence among parameters

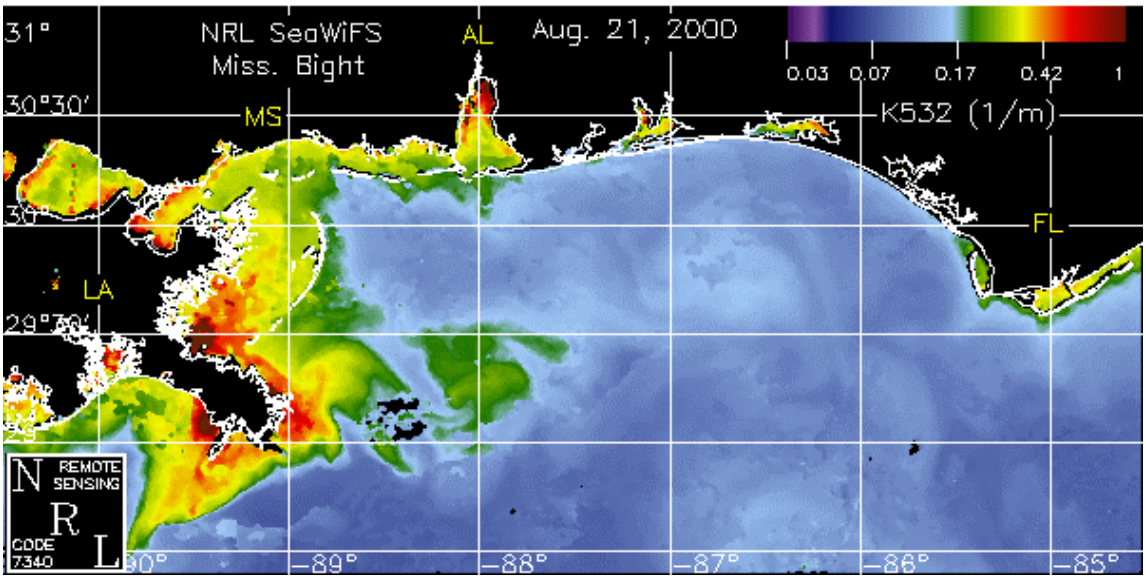

Figure 1. SeaWiFS derived K532 (m^{-1}) for August 21, 2001 (courtesy of R. Arnone, NRL Stennis Space Center). Center position of test range was 30°10.1N and 85°51.4W.

suggests high data quality. Beam attenuation at 532nm ranged between 0.19 and 1.02 (m^{-1}) in the surface waters, 0.37 and 1.40 (m^{-1}) within 1m of the bottom as determined by ac9 profiles at the main transect site. Similar near-bottom results were measured by the moorings at 10 minute intervals. Attenuation coefficients for downwelling irradiance at 532nm ranged between 0.08 and 0.26 (m^{-1}) at the surface and 0.8 and 0.28 (m^{-1}) near the bottom with a reversal of the turbid layer from the bottom during the first half of the cruise to the surface during the last half. We are continuing to process data at all wavelengths, and will build the temporal and spatial data sets using all the systems over the next few months.

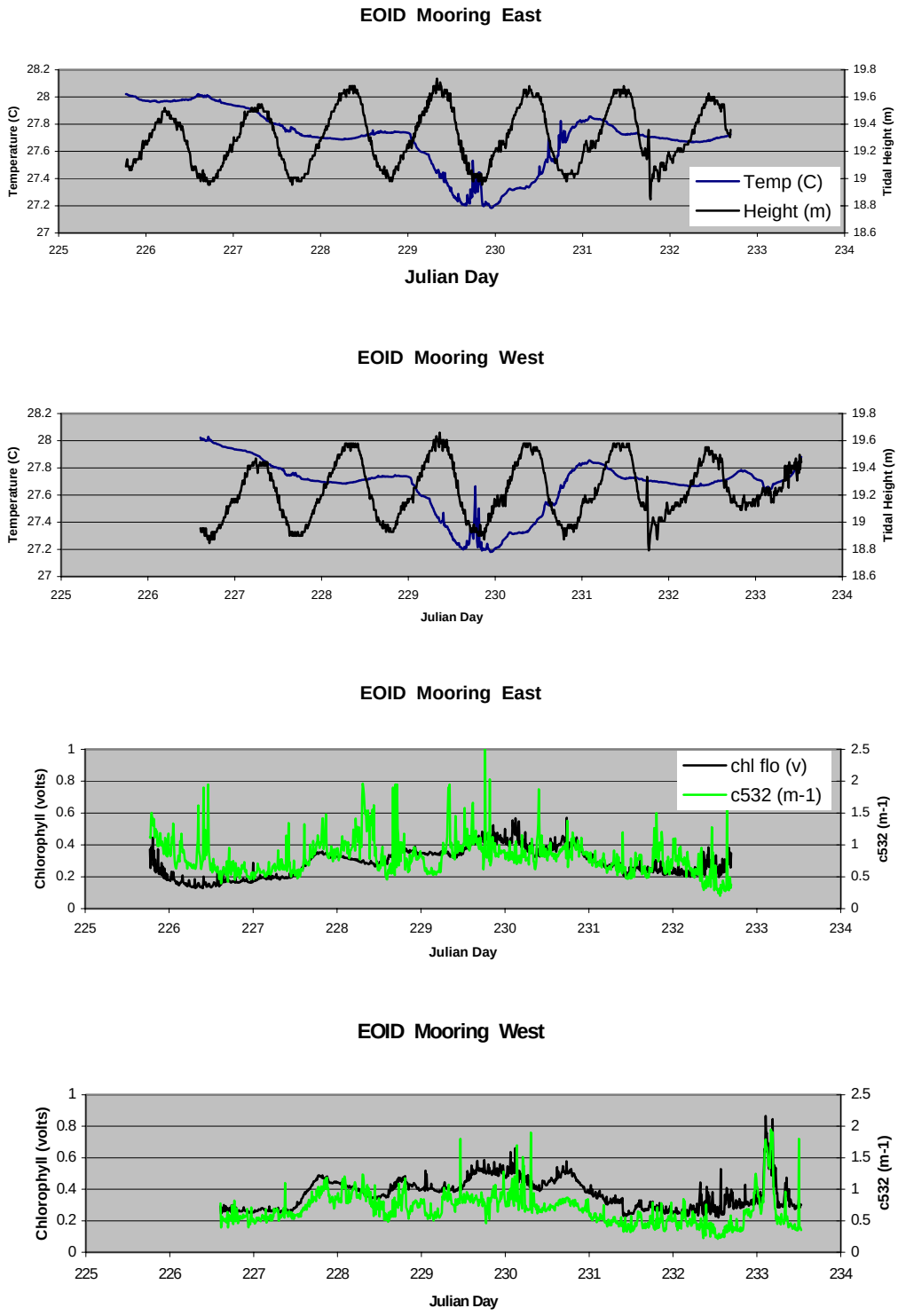

Figure 1. Physical and optical time series data for the east and west near-bottom moorings at the EOID site from Julian Day 225 to 233, 2001. Top panels: tidal height and temperature, bottom panels: chlorophyll fluorescence and c532 (m^{-1}). Coherence can be seen between the two sites and among parameters, with temporal differences observed in c532 between sites 200 feet apart.

IMPACT/APPLICATIONS

This work is an important aspect of the transition of laser imaging systems to the fleet for mine countermeasure operations. Our environmental data will contribute significantly to the models that will evaluate and predict sensor performance in a wide variety of operational scenarios. These models require accurate water column optical property data in order to quantify image quality parameters.

RELATED PROJECTS

This project was closely coupled with the work of Mazel (Psicorp, Inc.) and Voss (University of Miami) for the environmental characterizations in collaboration with a large group from the Navy's Coastal System Station, Panama City, FL. Metron, Inc. (Reston, VA) was responsible for data management as well as environmental and performance model development. Other modelers included Strand (CSS, Panama City) and the laser imaging system vendors (Arete, Raytheon and Northrop-Grumman).

PUBLICATIONS

Yentsch, C.S., S. W. Yentsch, C.M. Yentsch and D.A. Phinney. The relationship between visible and near-infrared reflected light from corals, macroalgae and micralgae. Submitted to CoBOP Special Issue of Limnology and Oceangraphy.

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